

Color typicality and content planning in definite reference

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Abstract

We investigated whether knowledge of the typical color of objects affects content planning in reference production. In a language production experiment, we elicited identifying descriptions of typically colored (e.g., orange goldfish) and atypically colored objects (orange crocodile). In line with our expectations, speakers are more likely to redundantly include color in a description of a target when it has an atypical color, than when it is typically colored. This finding leads to some recommendations for current computational models of content planning, such as the Incremental Algorithm.

Keywords: color typicality; content planning; visual saliency; models of reference production.

Introduction

In everyday language use, speakers often produce definite descriptions of target objects, and they aim to do this in such a way that their addressee is able to identify that target among surrounding distractor objects. When producing such referring expressions, speakers make decisions about which attributes of the target objects will be mentioned, a process which is often described as *content planning*. For example, a speaker could refer to the crocodile in Figure 1 by saying "the orange crocodile", which includes the attribute *color*.

Note that only using the noun "crocodile" here would be informative enough, as it rules out any of the other animals in the scene. Thus, the use of color illustrates that *informativeness* is not the only criterion speakers employ. One additional criterion in content planning is *visual saliency*. An object's color is a visually salient attribute, causing speakers to prefer to use it, even if it causes a description to be *over-specified* (Koolen, Goudbeek, & Krahmer, 2013a; Pechmann, 1989).

However, considering the example in Fig. 1, we propose that color is salient (and therefore mentioned) because orange is an *atypical* color for crocodiles. So, we assume that if a target attribute draws a speaker's visual attention, it is likely that it will be realized in a referring expression. There



Figure 1: A simple scene containing an orange crocodile. (Note that manipulations of color are not visible in some prints of this paper.)

are generally two ways in which attributes such as color can be visually salient and therefore draw visual attention. It can *perceptually* "pop out", for example when it contrasts with the colors of surrounding objects. But also, *conceptual* processes can make color particularly conspicuous (Itti & Koch, 2000), for example because it contrasts with stored knowledge. The former mechanism is known to affect content planning (e.g., Koolen et al., 2013a), but the impact of the latter is relatively unexplored.

We focus on one particular kind of conceptual visual saliency, namely saliency informed by common knowledge about the typical color of an object that a speaker refers to. Perceived objects that violate this common knowledge (such as the atypically colored crocodile in Fig. 1) attract visual attention (Becker, Pashler, & Lubin, 2007). But does that also affect the way in which such objects are described? In other words, does conceptual visual saliency, informed by object knowledge, influence content planning? This is the question that we address in the current paper. In the discussion section, we elaborate on the role of conceptual saliency for current algorithms in the field of Referring Expression Generation.

Background

When verbally referring to an object, speakers make a series of decisions on which attributes of the object they want to mention in a referring expression. This process of content planning has often been argued to rely on two components. For example, in a recent paper, Frank and Goodman (2012) proposed that a listener can recover an intended referent by assuming that speakers base their content planning on both the informativeness of the content and the saliency of the potential referents.

Informativeness is a computationally appealing criterion. It follows from Frank and Goodman (2012) that the more informative a word is, the more likely it is that it is realized in a referring expression. A word is especially informative when it can describe the target object in a scene, but not any of the distractors. As such, the word "orange" in a description of a referent in Fig. 1 is less informative than the word "crocodile" as "orange" designates an attribute that two potential referents have, instead of one. Computational models for automatic Referring Expression Generation (REG) are often based on informativeness to model the content planning for a referring expression. For example, the Incremental Algorithm (IA; Dale & Reiter, 1995), arguably the most influential model in REG (Van Deemter, Gatt, Van der Sluis, & Power, 2012), relies on a relaxed interpretation of

informativeness by only selecting an attribute if it excludes at least one of the distractor objects that are to be ruled out.

Besides informativeness, *saliency* has been argued to affect content planning as well. Frank and Goodman (2012) state that several kinds of saliency might play a role. For example, attributes that are salient in the discourse might be more relevant to mention than less salient ones (Krahmer & Theune, 2002). But in initial reference (when there is no prior discourse), it is likely that speakers include attributes that draw their visual attention. Visual attention is argued to be guided by at least two kinds of saliency cues: perceptual and conceptual cues (Itti & Koch, 2000).

Perceptual Cues *Perceptual* cues that guide visual attention are image-based cues, which are processed quickly in a primitive and pre-attentive manner (Itti & Koch, 2000). It concerns things like contrast and bright colors that make areas in a scene "pop out".

Such perceptual cues are known to affect human reference production: attributes that pop out more than other attributes are likely to be included. An obvious example is color, which is a perceptually salient attribute that is thus likely to be included in a referring expression, even if this leads to an *overspecified* description (i.e., one that includes more attributes than strictly required in terms of informativeness; Arts, 2004; Koolen et al., 2013a; Pechmann, 1989).

Interestingly, the current REG algorithms generally allow modeling of this observed preference for perceptually salient attributes. For example, the IA (Dale & Reiter, 1995) does this by applying a *preference order* (PO), which is a predefined order of all attributes that can occur in a certain domain, where preferred attributes are ranked before less preferred ones. The IA then considers the former before the latter. Crucially, the IA does that attribute by attribute, independently of each other. The PO is typically based on corpora of human-produced referring expressions (Krahmer & Van Deemter, 2012), which are in turn often based on perceptual visual saliency factors.

Conceptual Cues Besides perceptual mechanisms, a *conceptual* mechanism that involves cognitive effort is also known to guide visual attention (Itti & Koch, 2000). In this paper, we address a specific conceptual cue, which is related to intrinsic knowledge that people have about objects (e.g., that crocodiles are normally not orange; see Fig. 1). How does object knowledge guide visual attention?

For the specific case of color typicality, on which we focus in this study, extensive perception research has shown that color plays an important role in the recognition of perceived objects (e.g., Theriault, Yaxley, & Zwaan, 2009) and that an object's typical color is an intrinsic part of general knowledge about these objects (Naor-Raz, Tarr, & Kersten, 2003). Although shape is important in determining ("diagnosing") an object's identity (e.g., Biederman, 1987), color cues also play a significant role in the recognition of so-called *color-diagnostic* objects. Color-diagnostic objects are objects that have one or a few typical colors associated with them (Tanaka, Weiskopf, & Williams, 2001). Within the group of color-diagnostic objects, a further distinction can be made. The relative contribution of color in an object's

identity is highest for objects with a simple, uncharacteristic shape. Consider for example how important color is in distinguishing lemons from limes. But other objects have a very characteristic shape, making color less informative for identity (Tanaka et al., 2001). For instance, a banana is typically yellow, but its shape distinguishes it from many other objects. Therefore, some object types are more strongly related to their typical color than other types.

What is the role of atypical colors in visual saliency? An important finding is that perceived objects with attributes that "disobey" mental prototypes attract early visual attention. In an eye-tracking study, Becker et al. (2007) presented participants with naturalistic scenes that contained an object in an atypical color (e.g., a green hand). This object captured early visual attention in the scenes, which means that color atypicality as a top-down cue guides attention. Becker et al. controlled for perceptual saliency effects by swapping colors between objects in the scene.

Unlike what is the case for perceptual cues, how knowledge of an object's typical appearance affects content planning in reference production is much more of an open question. Are speakers inclined to mention a color that is atypical for a particular object (e.g., an orange crocodile), compared to when the same color is typical for another object (e.g., a goldfish)? And is such an effect of atypicality mediated by the strength of the link between the object and its color?

Mitchell, Reiter, and Van Deemter (2013) showed that speakers prefer to mention shape or material when that is atypical, but Mitchell et al.'s results did not reveal how the degree of correlation between type and shape or material affected content planning. For color, Sedivy (2003) demonstrated that speakers are more likely to mention color when they are to describe normally colored objects that can have any color (e.g., a mug) as compared to when they refer to an object that has a color that is typical (e.g., a banana). This suggests that speakers decide on including color on the basis of the type of the object, and that the strength of an object's connection to its color can mediate this process. However, the picture is far from complete, and empirical research into the effects of color atypicality on content planning is lacking.

Considering general knowledge about the typical color of objects in content planning offers a challenge for the current REG algorithms. The IA, for example, does not capture knowledge about the object referred to, and is thus not informed about a typical or atypical color of target referents. If color atypicality were indeed to affect reference production, this strengthens the idea that human speakers combine type and color information in the content planning process for initial reference. However, since the IA selects attributes independently in a one-by-one fashion, it will have a hard time combining attributes in a way that is similar to what human speakers do.

The Current Study In the language production experiment presented in this paper, we tested the impact of knowledge about the typical color of color diagnostic objects on content planning. We presented participants with visual scenes consisting of six objects, and asked them to provide a descrip-

tion of one of these objects (the *target*) such that another participant could distinguish it from the *distractors*. We manipulated whether the target object was atypically colored (e.g., orange crocodile) or typically colored (e.g., red strawberry), but we aimed to keep differences in perceptual saliency low by using the same colors in both typicality conditions. We also controlled for the informativeness of color by making sure that it was never needed to distinguish the target from the distractors. We hypothesize that because the color of an atypical object draws visual attention, color is more likely to be redundantly mentioned when speakers produce an initial target description.

We expect this effect to be mediated by the strength of the connection between an object's color and its type. As we have seen in the object recognition literature, shape interacts with color: color is highly important for recognizing simply shaped objects, but not necessarily for objects that have a more complex and therefore a more characteristic shape (Tanaka et al., 2001). So, we also varied whether the objects we used were objects with relatively simple shapes (such as an apple and a tennis ball), or whether they had relatively complex shapes (such as a fire truck and a lobster).

Experiment

Method

Participants Sixty-two undergraduate students in communication sciences participated in pairs. Thirty-one (7 males) acted as speakers, the others acted as addressees. All participants were native speakers of Dutch (the language of the study) and participated for course credits. They were not instructed about the conditions in the experiment.

Materials The experimental materials consisted of sixteen scenes containing six color photographs of single objects. The object types were selected on the basis of stimuli used in object recognition studies (e.g., Theriault et al., 2009). For each object, a high quality photo was selected, and the object was placed on a plain white background. Each scene contained three typically colored and three atypically colored objects, positioned randomly in a three by two grid. One of the objects was the target object, and was clearly marked for the speaker with a black square.

Crucially, the target object was either typically colored (e.g., red tomato) or atypically colored (yellow tomato). The typical colors of the objects were either red, green, yellow, or orange, and these colors were rotated across the objects to create atypically colored versions. Therefore, all four colors were used equally often in both typicality conditions, in order to ensure that potential perceptual saliency effects caused by certain colors were minimized. Also, each scene contained three different colors (each on two objects) so that the target object's color was never unique within the scene.

The target object was always of a unique type within the scene, so mentioning color was never needed to distinguish the target from the five distractors. The target and all distractors were objects with either simple, uncharacteristic shapes (like tomatoes or apples), or with more complex, characteristic shapes (like bananas or crocodiles). Further-

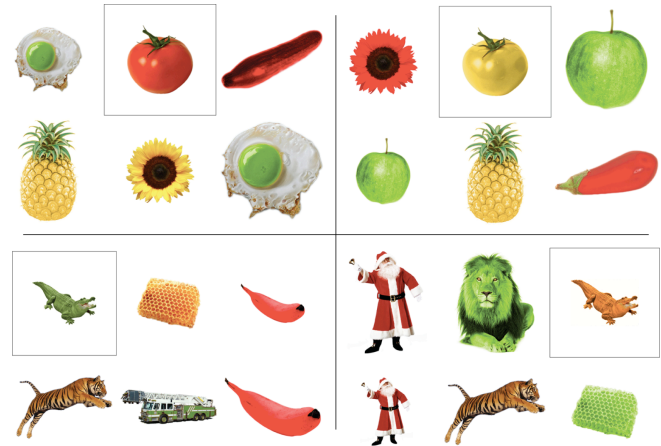


Figure 2: Examples of critical trials in the experiment as seen by the speakers, in both color typicality conditions (horizontal axis) and in both shape complexity conditions (vertical axis). The target was marked with a black square.

more, each scene contained three larger and three smaller objects, in order to introduce an additional attribute on which the objects differed from each other. The size of the target was counterbalanced throughout all the conditions in the experiment. Figure 2 presents examples of critical trials in all four typicality/complexity conditions: the scenes on the left contain a typically colored target referent, while in the scenes on the right this referent has an atypical color. Furthermore, the upper scenes contain objects with shapes that are more simple and less characteristic than the shapes of the objects in the lower scenes.

Procedure Each speaker described the sixteen critical scenes, as well as thirty-two filler scenes. These filler scenes consisted of four hard-to-describe "greebles" (Gauthier & Tarr, 1997), all purple, so that participants were not primed with color in these filler trials. We made two lists containing the same critical trials, but with reversed typicality: target objects that were typically colored for one speaker were atypically colored for another. As such, color typicality and shape complexity were manipulated within participants, while ensuring that each target object appeared in only one typicality condition for each participant. The order of the scenes in each list was randomized for each participant, but we ensured that there were always two filler scenes between experimental scenes.

The experiment was performed in an office room at our university, with an average running time of about 15 minutes. Participants took part in pairs. Who was going to act as the speaker and who as the addressee was decided by rolling a dice. Participants were seated opposite each other, and each had their own computer screen. The screens were positioned in a way that they did not obstruct the face of either participant, such that eye contact was possible. The speaker was presented with the 48 trials on his or her computer screen, one by one, and described the target objects in such a way that the addressee would be able to uniquely identify them. The instructions emphasized that it would not make sense to include location information in the descriptions, as

the addressee was presented with the objects in a different order. The speaker could take as much time as needed to describe the target, and his or her target descriptions were recorded with a microphone.

The addressee was presented with the same 48 trials on his or her own computer screen, but with the objects in a different order, and without any marking of the target object. The addressee was asked to mark the picture that he or she thought the speaker was describing on an answering sheet. The instructions emphasized that the addressee was (to a limited extent) allowed to ask for clarification: It was allowed to ask the speaker to give more information or to repeat information that had already been given, but not to ask for specific information (i.e., specific attributes). However, there were no requests and thus clarifications by our speakers, so the data presented here should be regarded as initial references.

There were three practice trials, two with greebles and one with six natural objects that did not have any typical color associated with them (chair, marker, backpack, book, desk lamp, mug). Once the addressee had identified a target, this was communicated to the speaker, and the experimenter pressed a button to advance to the next trial. Recordings and stimulus randomization were administered with E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002). After completion of the experiment, none of the participants indicated that they had been aware of the actual goal of the study.

Results

In total, 496 target descriptions were produced in the experiment. Over 95% of these descriptions ($n=472$) contained a (correct) type attribute, resulting in unique reference. Using the correct type was important, because otherwise we could not deduce whether the object's color was regarded as typical or atypical. So, in the following analyses descriptions containing an incorrect type attribute (e.g., "fruit" instead of "lemon") were excluded.

We analyzed whether color was mentioned in the referring expression using logit mixed models (Jaeger, 2008). Initial analyses revealed that stimulus list had no effects, so this was left out in any further analysis. In our model, color typicality and shape complexity were included as fixed factors. Both factors were centered around their respective means to reduce collinearity. Participants and target object types were included as random factors. The model had a

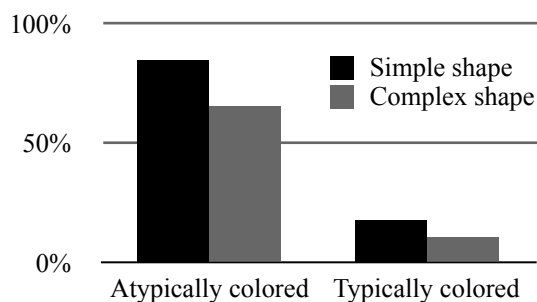


Figure 3: Proportion of referring expressions containing a color attribute as a function of color typicality and of the structural complexity of the target referent.

maximal random effect structure: random intercepts and random slopes were included for all within participant and within item factors, to ensure optimal generalizability (Barr, Levy, Scheepers, & Tily, 2013).

Our analysis, as shown in Figure 3, revealed a significant main effect of color typicality ($\beta=7.06$, $SE=0.78$, $p<.001$), as 75.3% of the references to an atypically colored target contained a color attribute, compared to 14.3% of the references to a typically colored target.

Furthermore, there was a main effect of shape complexity ($\beta=-1.78$, $SE=0.69$, $p<.025$), as 49.1% of the references to an object with a simple shape contained color, compared to 38.4% of the references to a complexly shaped target. Color typicality and shape complexity interacted ($\beta=-2.79$, $SE=1.28$, $p<.05$): the effect of color typicality on mentioning color was slightly larger for simple objects than for complex objects.

Discussion

Our results clearly show that atypicality affects content planning. When a referent object has an atypical color, speakers are significantly more likely to redundantly include color in a referring expression, than when a referent has a typical color. This happens irrespective of simple perceptual saliency caused by the object's color, as we have used the same colors throughout all conditions in our experiment. The effect of atypicality on content planning appears to be mediated by the degree of connectedness between an object's type and its color. We argued that an object's color is more prominent for object types that have a simple and uncharacteristic shape, and it is for these objects that the effect of atypical colors on content planning is the largest.

The current results show that speakers utilize general object knowledge about the referent object in content planning for initial reference. General object knowledge contains information about the typical color of objects (Naor-Raz et al., 2003). When a property of an object in a visual scene contradicts this information, speakers tend to include this property in an identifying description of that object. This is an effect of conceptual visual saliency on content planning: a speaker assesses stored object knowledge in order to determine whether an object is atypical or not.

Our findings resonate with other research on the influence of conceptual knowledge on content determination. It corroborates the findings of Mitchell et al. (2013), who show that atypical materials and shapes are preferred over typical ones in content determination, and the finding of Sedivy (2003) that decisions on mentioning an object's type and color are not taken independently of each other.

Our study also sheds light on the recent tendency to focus on more naturalistic stimuli in the study of visual perception and reference production (see, for example, Coco & Keller, 2012; Koolen, Krahmer, & Swerts, 2013b; and Mitchell et al., 2013). One important difference between the real world and such artificial scenes lies in the color of the objects used: in artificial scenes objects are often atypically colored. Our results show that reference production can be affected by the artificial nature of objects used in some experiments.

Our results suggest that the effect of color atypicality on content planning is connected to conceptual saliency, guided

by object knowledge. Atypically colored objects attract visual attention (e.g., Becker et al., 2007), and we assume that if a target attribute draws a speaker's visual attention, it is likely to be mentioned in a referring expression. This can be characterized as a speaker's decision that is based on a simple *heuristic* (as suggested by Van Deemter, Gatt, Van Gompel, and Krahmer, 2012). Heuristics "reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations" (Tversky & Kahneman, 1974, p. 1124). Our results strongly suggest that speakers do not always consider the properties of a target object and distractors in terms of informativeness, but that the visual attention drawn by certain properties (because they are atypical) also guides the decision to mention these properties in a description. This is arguably simpler to do than to consider the distinguishing value of properties. Because the choice of speakers in our experiment to mention color seems to be almost fully explained as a function of typicality, a heuristic concerning typicality may be relatively easy to model in REG.

Implications for REG algorithms

So, what specific repercussions do our observations have for computational models of reference production (REG algorithms), such as the Incremental Algorithm (Dale & Reiter, 1995)? In the IA, attributes are included in a referring expression on the basis of their informative value. More salient attributes, like color, are considered early, because they are highly ranked in a predefined preference order (which is typically determined on the basis of empirical data). Assuming that type is likely to occur at the head of the PO (because it is necessary to create a proper noun phrase) and is therefore selected first, the IA would generate no color adjectives in neither of the conditions of our experiment (where mentioning type was always sufficient for unique identification). So, the preferences of the speakers in our experiment appear not to be based on a ranking of attributes (e.g., color, size, etc.), but of a ranking of attribute *values* (e.g., red, green, etc.).

Furthermore, content planning depends on the degree of typicality of the color attribute value, *with respect to the type*. To determine this typicality, a simple kind of world knowledge is required that informs the model. One possible implementation is to compile a knowledge base that contains typical object information, which can be queried at runtime when a referring expression is generated (Mitchell et al., 2013). However, for color, a simpler solution that does not require a dedicated knowledge base may be effective. A web search for images showing the concerned object type, combined with a simple computer vision algorithm that measures the first n results' dominant color, can inform the REG algorithm about what a typical color for the object is. It can even shed light on the question *to what extent* a color is typical, by comparing the n search results showing the dominant color to the n results showing other colors.

Future work

In our study, we have varied shape complexity to operationalize the strength of the connection between an object's type

and color. Color is more prominent for objects with a simple shape than for objects with a more characteristic complex shape (Tanaka et al., 2001), and the effect of atypical colors on overspecification appeared to be larger for simple target objects than for complex ones. However, future work should aim to disentangle this effect from a potential bottom-up saliency effect caused by the larger color area that simple objects have compared to complex objects.

Furthermore, we explain the content planning process as reliant on the speaker's perception of the objects that are described. However, our data does not allow us to address the question as to what extent a speaker's conception of the addressee's perspective plays a role when referring to atypical objects. One possible explanation for our findings concerns the *speaker's* visual recognition process of objects. Because recognizing atypically colored objects is slightly slower than recognizing typically colored ones (e.g., Theriault et al., 2009), it is possible that a speaker specifies the object's color just to start speaking in reasonable time. Future work can aim to test this explanation, for example by replicating the current experiment in a language which realizes color as a post-nominal modifier.

On the other hand, if a speaker takes his or her own visual attention as a *proxy* for the *addressees* attention, mentioning color can be regarded as a pragmatic consideration tailored to the addressees needs for identifying the referent. Further research can aim to investigate this account, for example by varying the degree to which atypicality is useful for the addressee for unique identification.

In future work, we aim to expand our observations to other ways in which object knowledge may affect content planning. Objects can not only be atypically colored, but can be atypical in a context as well. From perception research, it follows that objects that are atypical in a certain context (e.g., an octopus in a barnyard) draw visual attention (Loftus & Macworth, 1978). If that affects content planning as well, it adds up to converging evidence that visual attention, informed by top-down object knowledge, plays an important role in initial reference.

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